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ABSTRACT

A 3-year study applied the four-dimensional pedagogical theory and model of transitional bilingual education in a school with a large Hispanic population, using mathematics content as the vehicle for teaching English. Subjects were approximately 200 fifth-grade limited-English-proficient (LEP) students in three cohorts in a 6-week voluntary summer program. Data on student achievement were drawn from Spanish and English math pre- and post-tests, with the students selecting the test language. The principal aims of the program were to improve LEP student achievement in math using both languages, and to prepare the students for middle school and help them maintain math skills during the summer. Results indicate overall mathematics improvement over the 3 years of the study, ranging from 3-27 percent gains in the four assessed areas of mathematics (fractions, charts and graphs, measurements and geometry, problem-solving); no negative differences or equivalent scores were noted. Overall score gains were 22 percent for the first cohort, 14 percent for the second, and 8 percent for the third. Annual gains differed for the four skill areas. In anecdotal reports, teachers reported more strengths than weaknesses in the program. Overall, the experiment was found successful. (MSE)

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Running head: BILINGUAL EDUCATION THEORY/MODEL

A Three Year Study of a New Pedagogical Theory/Model in a Bilingual Education Program Using Mathematics as a Vehicle of Instruction

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A Three Year Study of a New Pedagogical Theory/Model in a
Bilingual Education Program Using Mathematics as a Vehicle of Instruction

Most bilingual education classrooms in our society are transitional in nature with the goal being the acquisition of the English language (Development Associates, 1984; García, 1994) through the mastery of all subject matter, while demonstrating respect for students' native language and culture. The premise for this type of program is based on research that demonstrates as children gain more competence in the native language, the process of second language acquisition is advanced (Chomsky, 1988; Cummins, 1984; Hakuta, 1986; Krashen, 1985; Snow, 1987). Although the transitional classroom or program may have the same underlying premise, there are great variances in the way this premise is achieved. In fact, classrooms with the same goals may look very different inside (Cziko, 1992; Lam, 1992).

There are several reasons that this phenomenon may occur. A primary reason may revolve around the definition of bilingual education itself, where definitions are so broad that they relate very little about the teaching/learning processes occurring in the classroom, their variety, and their patterns of occurrence (Escamilla, 1992; Strong, 1986). Another reason may be the labeling of bilingual classrooms as bilingual where nearly exclusive English instruction is not uncommon (Losey, 1995; Sapiens, 1982; Vasquez, 1993). Another problem may lie in theory. The main theoretical foundations for bilingual education have been transported or extended from other fields such as sociology, linguistics, and anthropology. Furthermore, theoretical validation research typically is not from classrooms. Research findings are translated to the classroom environment from very different contexts. Language development studies typically are based on

communication in natural situations (Krashen, 1985a). Yet classrooms are much more focused, directed, and more complex language learning environments than most more "natural" situations.

The lack of instructional and curriculum guidance for bilingual classrooms leads to lack of definitional clarity with a wide variety of classroom practices passing for bilingual education. The field of bilingual education has failed to operationalize and particularize its propositions and principles to offer concrete guidance to teachers (Lara-Alecio & Parker, 1994). Another reason for the differences among bilingual classrooms as addressed by Cziko (1992) and Lam (1992) is the lack of demonstrable effectiveness of bilingual education. This is understandable, because without well-defined instructional activities for bilingual education, we are unlikely to be able to accurately measure their effectiveness. Trueba (1989) states "...researchers and practitioners ultimately need to find more useful theories and possible explanations that permit them to improve instructional design" (p. 21).

In spite of these recognizable concerns in the field, only one theory or model has been developed that addresses the pedagogical aspects of bilingual education (Lara-Alecio & Parker, 1994; Bruce, Lara-Alecio, Parker, Hasbrouck, & Weaver, 1996). Other models or theories address the linguistic nature of the learner rather than the instructional components of the transmission or the facilitation of learning through subject matter. This study is an examination of the four-dimensional pedagogical theory/model for transitional English bilingual classrooms (TBP Theory/Model) (Lara-Alecio & Parker, 1994). The TBP Theory/Model incorporates and operationalizes elements of classroom instruction supported by commonly espoused pedagogical principles of bilingual education (Cummins, 1986; Díaz, Moll, & Mehan, 1970; Fishman, 1976; Krashen, 1981a, b; Trueba & Barnett-Mizrahi, 1979; Trueba & Delgado-Gaitán, 1988; Trueba, 1979) which include the following:

- provide an emotionally supportive environment;
- emphasize quality of social interaction between teacher and student;
- ensure "bilingual" status is not considered a disability;
- provide quality social interactions between teacher and student;

- provide multi-modality interactions with students;
- incorporate minority students' culture in teaching;
- guide and facilitate rather than control student learning;
- encourage student talk and independent learning;
- structure activities which facilitate quality interactions;
- encourage community participation in schooling;
- promote student intrinsic motivation;
- teach "meaningful" content;
- develop prior competency in the home language; and
- continue to develop competencies in both languages.

These elements of instruction are included as interrelated dimensions of the TBP Theory/Model. The four elements are depicted in Figure 1 and followed with a brief discussion: (a) Activity Structures, (b) Language Content, (c) Language of Instruction, and (d) Communication Mode.

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Place Figure 1 about here

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Activity Structures are teacher-structured learning situations, each with its own expectations for teacher and student communication (Brophy & Evertson, 1978; Doyle, 1981). Activity structures are relatively stable, recurring periods of activity, each with a recognized purpose and opportunities for communication. Language Content within the theory derives directly from Cummins's (1986) influential distinction of Basic Interpersonal Communications Skills (BICS) and Cognitive-Academic Language Proficiency (CALP) language competencies. The four dimensional pedagogical theory reformulates BICS and CALP into malleable levels of discourse, rather than as fixed or long-term abilities. It has a total of four levels of language content: 1. Social Routines (i.e., social exchanges and conversation); 2. Academic Routines (i.e., preparing for recess, returning books, learning strategies, handing in assignments, structuring homework); 3. Light Cognitive Content (i.e., current events, discussion of the school fiesta, repetitive drill

and practice); and Dense Cognitive Content (i.e., new content-area information, conceptually loaded communication with specialized vocabulary and procedures). The Language of Instruction within the theory has four different combinations of native language and English: I. Content presented in L1 (indicates Spanish-only instruction, a beginning point for students with very low English proficiency); II. L1 introduces L2 (indicates instruction primarily in L1, but additionally, English vocabulary is taught for key ideas concepts and procedures); III. L2 clarified by L1 (indicates instruction primarily in English, but with L1 used as a "back-up" as needed, to ensure understanding); and IV. Content presented in L2 (indicates English-only instruction, the goal). The order of these four combinations may change and overlap. Communication Mode indicates within the TBP Theory/Model that English facility may vary greatly by mode (reading, aural reception, speaking and writing),and that each mode should be permitted to progress at the fastest rate possible (Lara-Alecio & Parker, 1994).

Method

The study was conducted with 200, 5th grade limited English proficient (LEP) students in an urban public school in the Houston, Texas area with a large bilingual (Hispanic) population using mathematics content as the vehicle of instruction in a 6 week summer program. The three groups of participants in the study (one group per year) were selected on the basis of scores below the 23%tile on the Spanish Assessment of Basic Education (SABE) and below the 23%tile of English standardized achievement tests in reading and language arts. These scores were criteria upon which the students were admitted to the summer program. Students came on a voluntary basis to the summer program and were provided transportation, free breakfast, and lunch. The program employed eight bilingual, Spanish/English certified teachers and eight bilingual Spanish/English aides to work with the students each summer. The teachers were provided a curriculum and methodology using the TBP Theory/Model.

Data were collected over the three year, 6 week summer program through English/Spanish pre-post math test comparisons, with students being given the opportunity to choose the language version of the pre-post tests. The principle objectives of the summer

program were to: (a) improve the academic achievement of LEP students in mathematics using both the Spanish and English language, and (b) prepare the students for middle school and to ensure that they maintained math skills during the summer recess.

The research focused on the hypothesis that by introducing content (mathematics), particularly dense cognitive content (Lara-Alecio & Parker, 1994), in the student's primary language (Spanish), conceptual understanding (CALP) would be assured. Once the concept was understood by the student, elaboration would follow in the second language (English). The research focused on the acquisition of mathematics skills in four areas: (1) problem solving; (2) measurement and geometry; (3) graphs and charts; and (4) fractions. The math assessment tool used was The Criterion Math Test (Parker & Lara-Alecio, 1991) which was developed with equivalent forms matched by item in a counterbalanced administration. This test was based on school district curriculum and state essential elements.

Data were analyzed in the following ways: (a) overall improvement in mathematics skills over the six week period, (b) disaggregated data focused on the specific math concept (fractions, charts & graphs, measurements & geometry, and problem-solving), and (c) comparison of pre-post test results from year to year. Descriptive statistics were employed as was a two-tailed *t*-test of significance.

Anecdotal records from 5 of the eight bilingual certified teachers (62%) who were consistent with the project over the three year period were gathered and reported in terms of strengths and weaknesses.

Results

Results indicate that students made overall math improvement during the three years as depicted in Table 1. The overall gain scores ranged from 3% to 27% gains in any of the four assessed areas of mathematics. No negative differences or equivalent scores were noted within the three years. Overall gain scores of the students each year were reported at 22% for the first year, 14% for the second year, and 8% for the third year. Significant gain scores at either the $p<.01$ or $p<.001$ significance levels were determined for two areas for all three years: (a)

Measurement and Geometry and (b) Fractions. Problem solving and Graphs & Charts were two areas that had reported significant gain scores for the first two years but not the third year at the p <.01 or p<.001 significance level. The Total Score report was statistically significant only for the first two years of the program.

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Place Table 1 about here

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Table 2 presents disaggregated data of pre-test and post-test data, focused on the specific math concepts -- fractions, charts & graphs, measurements & geometry, and problem-solving. For the three years of reported data in the assessed area of problem-solving, the participants made greater gains during the first year (13% gain) and declined in gain scores the following two years (11% and 4%, respectively). Measurement and geometry were assessed for the three years and yielded the following results: Year 1-- 19% gain; Year 2 -- 20%; and Year 3 -- 9%. Graphs and Charts were assessed with the first year group having a gain score of 22%, second year 21%, and third year 3%. In the assessed mathematical area of fractions, the students scored better during the first year of the program with a gain score of 27% and with gain scores in the second and third years at 8% and 9% respectively. Statistical significance was established at the p<.01 and p<.001 levels.

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Place Table 2 about here

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The anecdotal records of the consistent project teachers (5 teachers, 62%) were reported in terms of strengths and weaknesses. They reported almost twice as many strengths as weaknesses.

Overall, these teachers indicated strengths of the program to be: (a) small classes with individualized instruction, (b) team teaching, (c) free breakfast and lunch for the students, (d)

active parental involvement, (e) all classes doing the same thing which promoted unity, (f) well-organized program, and (g) good communication with all teachers and university personnel. Specifically, regarding curriculum and instructional matters, they reported strengths as: (a) structured schedule with little wasted time, (b) real-life reasons for mathematics, (c) varied materials, (d) access to teacher resources, (e) pre-designed homework/writing assignments, (f) computers and printers, (g) no mandatory evaluations/portfolios, (h) students used both languages, (i) teachers used both languages to teach concepts, and (j) students had opportunities to practice and share reading and writing.

In general, the weaknesses reported were programmatic in nature. Such weaknesses were: (a) limited Spanish software, (b) need for planning time during the day, (c) need for greater variety of books, (d) need for more feedback on pre-tests, (e) too much out-of-class assessment, (f) need more specific objectives in mathematics, (g) need more field trips, (h) more time needed to work on English language skills-- so many of the students were at a low level in L_2 acquisition and needed most concepts taught in Spanish, and (i) set a break for teachers.

Discussion

Teacher anecdotal records by those who participated in the program over a three year period indicate a positive response to such a program. Perhaps some of the gain score results that are lower in nature can be explained by some of the negative comments of the teachers regarding the need for specific feedback on pre-tests results so that instruction could be targeted to the lower achieving areas, as well as a longer period of time for such a program to occur so that even more time could be spent in better targeting and improving English skills. It appears that such enrichment programs assist students when they have small classes and can have more attention to their language development through content areas.

The principle objective of the study was to determine whether academic achievement of LEP students in mathematics could be improved using the TBP Theory/Model where the language knowledge already possessed by the students in both English and Spanish could be employed for better understanding. The study was based on the assumption that English fluency

can efficiently be developed through content-area instruction, in this case mathematics. The TBP Theory/Model as validated through the mathematics content acquisition was determined to have positive utility effects in the bilingual classroom.

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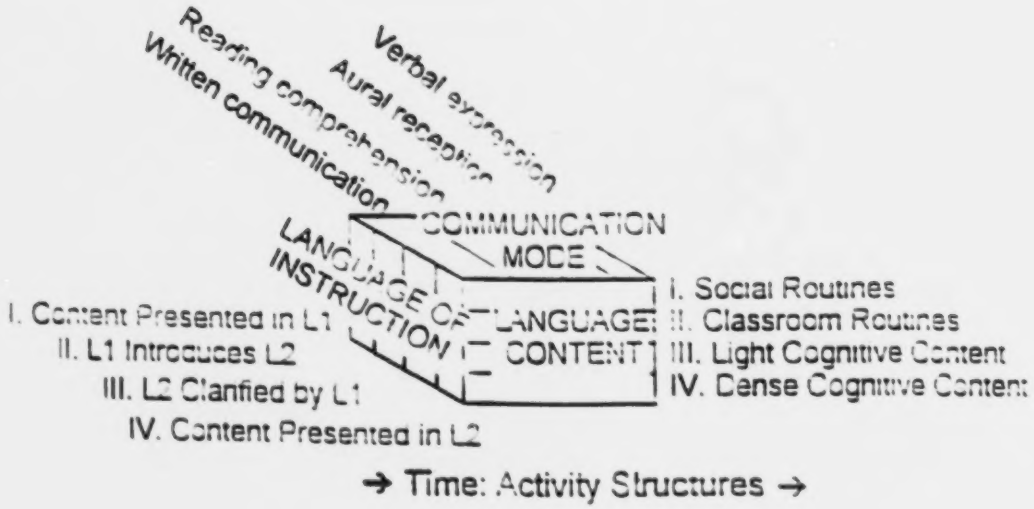

Figure 1
Pedagogical Theory: Four Dimensional Model

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Table 1 -- Overall Math Improvement Results (1993 through 1995)

	1993 N	1993 Gain	1994 N	1994 Gain	1995 N	1995 Gain
Problem Solving	67	13%*	63	11%*	82	4%
Measurement & Geometry	67	19%**	63	20%**	82	9%*
Graphs & Charts	65	22%**	61	21%**	82	3%
Fractions	66	27%**	60	8%*	82	9%*
Total Score	66	22%**	62	14%*	82	8%

* = p< .01 ** = p<.001

Table 2- Pre-Post Test Math Gains: (Year 1 , 2, & 3)

	Year 1 (1993)				Year 2 (1994)				Year 3 (1995)			
	Pre N	Test M	Post M	Test Gain	Pre N	Test M	Post M	Test Gain	Pre N	Test M	Post M	Test Gain
Problem Solving	67	39	52	13% *	63	41	52	11% *	82	37	41	4%
Measurement & Geometry	67	24	51	19% **	63	23	43	20% **	82	24	33	9% *
Graphs & Charts	65	23	45	22% **	61	26	47	21% **	82	26	28	3%
Fractions	66	22	49	27% **	60	24	32	8% *	82	14	23	9% *
Total Score	66	27	49	22% **	62	26	41	14% *	82	22	30	8%

* = p< .01 ** = p<.001

Note: Mean Scores are Expressed in "% Correct"

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